Single Atom Interferometry with neutral atoms in a state-selective 1D optical lattice

Individual Cs atoms are conditionally trapped depending on their internal hyperfine state in a standing wave composed of two orthogonal polarizations. By displacing the latter relative to each other, we coherently transport atoms across the lattice and/or spatially split and spread the atomic wavefunction across several lattice sites. We are thus able to perform single atom interference experiments, in particular, repeated application of a $\pi/2$ -pulse and a transport step realizes a quantum walk with up to 24 steps, allowing us to observe superclassical spreading of the walk as well as recombination to a single site by unitary reversal. Adding state-selective detection, a full state tomography could be performed[1]. State selective transport makes it also possible to coherently control the quantum mechanical motion of atoms in the lattice through microwave sideband transitions, which in turn allows microwave induced ground-state cooling of the atomic longitudinal motion[2].

[1] Michal Karski*, et. al.*, Science **325**, 174 (2009)

[2] Leonid Förster *et. al.,* Phys. Rev. Lett. **103**, 233001 (2009)